Prehistoric Distribution of Stone Adzes on Hawai'i Island: Implications for the Development of Hawaiian Chiefdoms

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POLYNESIAN CHIEFDOMS, including those of Hawai'i, have been the focus of classic research concerning the development of cultural complexity. Service (1962) defined a *chiefdom* as characterized by permanently centralized redistribution of resources administered through the hereditary office of chief as well as social stratification in which all individuals are ranked according to kinship distance from the chief. At the time of European contact, Hawai'i consisted of several chiefdoms, each divided into districts, which in turn consisted of local territorial units or *ahupua'a*. This territorial hierarchy was accompanied by a hierarchy of chiefly offices. The head of the chiefdom was a paramount chief who appointed lesser chiefs to administer the districts and *ahupua'a*. At each level of the hierarchy food and other materials were periodically collected to support the chiefs, who did not engage in subsistence activities, and to enable them to subsidize warfare, feasts, and ceremonies, or other public projects. The chiefly class, or *ali'i*, traced their ancestry to a senior ruling line. Rituals organized by a hierarchy of priests, material symbols of status, and an elaborate system of taboos all served to legitimize and maintain their political power (Earle 1978; Sahlins 1958).

Service (1962, 1975) proposed that chiefdoms develop in areas with marked environmental differences where centrally located settlements with preferential access to varied natural resources emerge as redistributive centers. Social stratification follows redistribution, as individuals prominent in economic activities come to hold hereditary offices and maintain or increase their influence through the efficient management of regional specialization and exchange. Service's hypothesis was followed by others that proposed that complex societies develop in response to environmental

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circumstances requiring centralized economic management (Brumfiel and Earle 1987:2). Few attempts have been made, however, to test Service's original hypothesis with archaeological data.

Earle (1977, 1978) used ethnohistoric data to test the applicability of Service's redistributional hypothesis in Hawai'i. He rejected Service's hypothesis, noting that in Hawai'i the local *ahupua'a* encompassed parts of all available environmental zones, so that the need for regional redistribution of resources did not exist. He observed that any ecological differences between regions were resolved by the pursuit of different subsistence strategies rather than reliance on exchange. Earle also suggested that the redistribution characteristic of Hawaiian chiefdoms was actually a form of "taxation" used to support the elite and did not involve the widespread redistribution of necessities. Furthermore, this redistribution was ceremonial in focus and irregular in occurrence, and it could not have functioned to ensure distribution of subsistence items. Earle suggested that the key to the development of Hawaiian chiefdoms was not the distribution or redistribution of resources per se as Service had argued, but rather the use of certain resources to finance other status-earning activities.

Earle has proposed a "dual economy" for the Hawaiian chiefdom consisting of a "political economy," characterized by "redistribution" in which food and other resources were collected to finance chiefly institutions, and a "subsistence economy," characteristic of the largely self-sufficient local communities within the chiefdom. He has also said that small-scale, reciprocal, and unregulated exchange in certain resources such as adze stone probably took place at the local level (Earle 1987:66).

My research is an attempt to use archaeological evidence to study the distribution of a material resource in Hawaiian chiefdoms and to allow further evaluation of the role of redistribution in the development of this complex society. Specifically, this article focuses on the spatial and temporal distribution of adze stone on Hawai'i Island and the implications of these distributional patterns for prehistoric Hawaiian exchange systems and the development of complex chiefdoms in Hawai'i.

METHODOLOGY

Preliminary tests by Cleghorn, Dye, Weisler, and Sinton (1985) indicated that stone from known adze quarries throughout the Hawaiian Islands could be differentiated petrographically. I selected 155 partial adzes and polished adze fragments from 35 archaeological sites in 19 different areas or localities of Hawai'i Island (Fig. 1; Table 1). Together with comparative samples from two known adze quarries, these artifacts were thin-sectioned and submitted for petrographic analysis. The artifacts were from previously excavated and dated archaeological sites and were obtained from several public and private collections. They were randomly selected to provide a sample of regions and temporal periods, but are not fully representative of the adze assemblages at individual sites. Dated sites or, when feasible, site components were grouped on the basis of mean corrected carbon 14 dates and/or mean volcanic glass hydration dates and placed in one of several temporal categories. These were defined as "before A.D. 1100," "A.D. 1100–1400," "A.D. 1400–1650," "A.D. 1650–1800," and "after A.D. 1800." No sites with suitable adze artifacts were found that dated to A.D. 1100–1400. Sites with dates spanning several of the time periods were placed in a category labeled "long sequence." Table 1 lists the 38 sites in chronological order with references used in assigning the temporal periods.

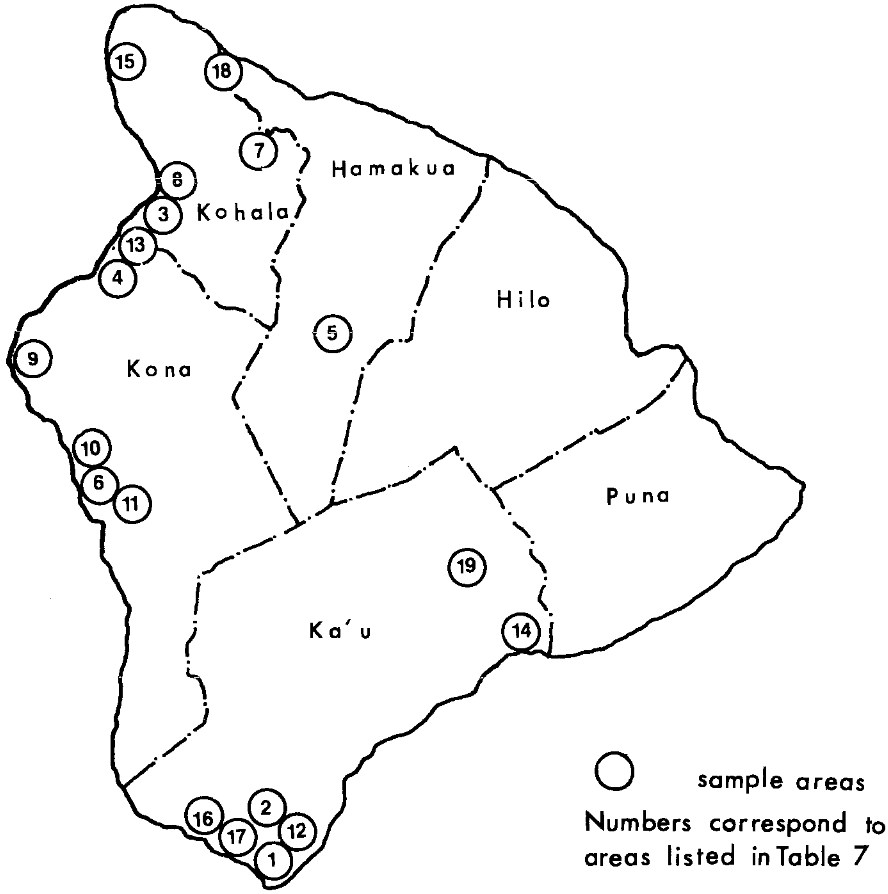


Fig. 1. Sample areas on Hawai'i Island. Numbers in circles correspond to locality numbers on areas listed in column 2 of Table 7.

RESULTS

Sources of Adze Stone

MAUNA KEA

Of the artifacts subjected to petrographic analysis, 102 or more than half matched thin sections of raw material from the Mauna Kea Adze Quarry. This quarry, located on the south slope of Mauna Kea, is the largest known adze quarry in the Hawaiian Islands; it is a complex of extraction areas, workshops, chipping stations, rockshelters, and shrines that extends over a total area of approximately 18 km^2. Analysis of the artifacts found at Mauna Kea (Cleghorn 1982) and other known quarry sites has shown that most stages of adze manufacture were carried out at these sites and that adze preforms or nearly finished but unpolished adzes were the actual products removed from the quarries. The stone from Mauna Kea is fine grained and well suited for adze manufacture, the result of rapid cooling during its formation (Cleghorn 1982; Cleghorn et al. 1985; McCoy 1977). Typically, thin sec-

TABLE 1. SITES USED IN PETROGRAPHIC ANALYSIS

SITE #[a]	LOCALITY[a]	PERIOD	REFERENCES
(1) H1	(1) H1	before A.D. 1100	Emory and Sinoto 1969; Goto 1986; Green 1971; Kirch 1985
(2) H8	(2) H8	before A.D. 1100	Emory and Sinoto 1969; Emory, Bonk, and Sinoto 1969; Green 1971; Goto 1986; Kirch 1985
(3) 324	(3) Kalahuipua'a	A.D. 1400–1650	Kirch 1979
(4) 368	Kalahuipua'a	A.D. 1400–1650	Kirch 1979
(5) 701A	(4) Kailua-Kawaihae	A.D. 1400–1650	Rosendahl 1973
(6) 5004	(5) Bobcat Trail	A.D. 1400–1650	Haun 1986
(7) D4-48	(6) Kahalu'u	A.D. 1400–1650	Kirch 1973
(8) D4-51	Kahalu'u	A.D. 1400–1650	Kirch 1973
(9) 7702	Kahalu'u	A.D. 1400–1650	Hay, Haun, Rosendahl, and Severence 1986
(10) 2727	(7) Mudlane-Waimea	A.D. 1650–1800	Clark and Kirch 1983
(11) 5998	Mudlane-Waimea	A.D. 1650–1800	Clark and Kirch 1983
(12) 8825	Mudlane-Waimea	A.D. 1650–1800	Clark and Kirch 1983
(13) 5625	(8) Ouli	A.D. 1650–1800	Rosendahl and Kaschko 1983
(14) 5627	Ouli	A.D. 1650–1800	Rosendahl and Kaschko 1983
(15) 8010	Ouli	A.D. 1650–1800	Rosendahl and Kaschko 1983
(16) 8018	Ouli	A.D. 1650–1800	Rosendahl and Kaschko 1983
(17) 4-16-6	(9) Kalaoa	A.D. 1650–1800	Cordy 1981
(18) D6-21	(10) Kuakini	A.D. 1650–1800	Schilt 1984
(19) D6-41	Kuakini	A.D. 1650–1800	Toenjes 1986
(20) D7-27	Kuakini	A.D. 1650–1800	Schilt 1984
(21) D8-52	Kuakini	A.D. 1650–1800	Schilt 1984
(22) 5611	Kahalu'u	A.D. 1650–1800	Hay, Haun, Rosendahl, and Severance 1986
(23) 7702	Kahalu'u	A.D. 1650–1800	Hay, Haun, Rosendahl, and Severance 1986
(24) T-1	(11) "Helco"	A.D. 1650–1800	Bath and Rosendahl 1984
(25) H2	(12) H2	A.D. 1650–1800	Emory and Sinoto 1969
(26) 2732	Mudlane-Waimea	after A.D. 1800	Clark and Kirch 1983
(27) 2776	Mudlane-Waimea	after A.D. 1800	Clark and Kirch 1983
(28) 8824	Mudlane-Waimea	after A.D. 1800	Clark and Kirch 1983
(29) 303	(13) Anaehoomalu	after A.D. 1800	Barrera 1972
(30) 73	(14) Pu'ueo	after A.D. 1800	Spear 1987
(31) 6941	(15) Lapakahi	long sequence	Tuggle and Griffin 1973
(32) 355	Kalahuipua'a	long sequence	Kirch 1979
(33) 1349	Kailua-Kawaihae	long sequence	Rosendahl 1973
(34) H65	(16) H65	long sequence	Kirch 1985; Soehren 1966
(35) 22-64	(17) Waiahukini	long sequence	Sinoto and Kelly 1975
(36) 22-248	Waiahukini	long sequence	Sinoto and Kelly 1975
(37) 4838	(18) Pololu	none	Tuggle 1976, 1987
(38) Big Ohia	(19) Volcanoes Park	none	none

[a] Site and locality designations are those used by references cited; numbers in parentheses are those assigned by the author.

tions of this stone have a texture of 130 or more g/mm and are dominated by lath-shaped plagioglase phenocrysts and microphenocrysts.

POLOLŪ

The second known source on Hawai'i Island is located in the Pololū Valley in North Kohala, and nine artifacts matched stone from this area. An adze workshop excavated here in 1974 (Olson and Nakama 1974; Tuggle 1976, 1987) was revisited in 1987 for sampling of source material. The site is a small but dense concentration of lithic debris beside the main stream in the valley floor. There is exposed stone in the valley wall near the site but no good evidence of actual quarrying activity. Stone samples from the valley wall, the stream bed, and the artifact concentration were thin sectioned and found to be of the same material type. In general, the Pololū material is coarser grained than stone from Mauna Kea, with most examples having a texture of approximately 100 g/mm. Diagnostic features include the general absence of phenocrysts, the fairly common occurrence of biotite in microphenocrysts and ground mass, and the alignment of small plagioclase laths to form a trachytic texture.

KĪLAUEA

On the basis of ethnohistoric accounts, a third quarry site is believed to have existed on Kīlauea Volcano, perhaps in or near Keanakāko'i Crater. It was destroyed by volcanic activity in the late nineteenth century (Cleghorn et al. 1985; Kamakau 1976:122). Efforts to locate evidence of the site in 1987 were unsuccessful, but several polished and unpolished flakes were collected at a previously reported habitation site near Kīlauea. Three artifacts from this site, the "Big 'Ōhi'a Shelter," were submitted for petrographic analysis and found to be olivine basalt, which is typical of the stone produced by Kīlauea lavas (MacDonald et al. 1986). Five artifacts from other parts of Hawai'i Island matched this material from Kīlauea. Thin sections are generally fairly coarse grained (less than 100 g/mm), and olivine phenocrysts are dominant. While it is impossible to determine whether this stone originated in the particular quarry referred to in ethnohistoric documents, the probable existence of a third source of adze stone in the Kīlauea area is indicated.

UNKNOWN SOURCES

A relatively large number of unknown sources of adze stone are also represented among the artifacts analyzed. Five artifacts seem to represent one material type labeled "Type A"; seven can be classed as "Type B"; and an additional four as "Type D." A final 20 artifacts seem to represent individually unique and unknown sources of adze stone. Although thin sections of stone from quarries on other islands have not been compared to the artifacts of unknown origin, there is no obvious correlation between any of the artifact thin sections and published petrographic descriptions of material from off-island adze quarries (Cleghorn et al. 1985). Most of the unknown materials are much coarser grained than the stone from known sources, with textures that are less than 100 g/mm, commonly 50–60 g/mm, and sometimes as coarse as 35 g/mm.

TABLE 2. ARTIFACTS PER MATERIAL CATEGORY

MATERIAL	NUMBER OF ARTIFACTS
Mauna Kea	102
Unknown sources	20
Pololū	9
Kīlauea	8
Type B	7
Type A	5
Type D	4
Total	155

Frequencies

Specimens from Mauna Kea occur most frequently, followed in order of decreasing frequency by Pololū, Kīlauea, Type B, Type A, Type D, and individual specimens from unidentified sources (Table 2). The last of these, considered collectively, number more than the other types with the exception of Mauna Kea. Given the large amounts of high-quality stone apparently available at the Mauna Kea Quarry, it is interesting that so many other sources of stone also seem to have been used. This suggests the existence of several other, probably small, quarry sites on Hawai'i Island. Also indicated, particularly by the unique and unknown materials, is the use of isolated pieces of suitable stone that were not obtained from a quarry.

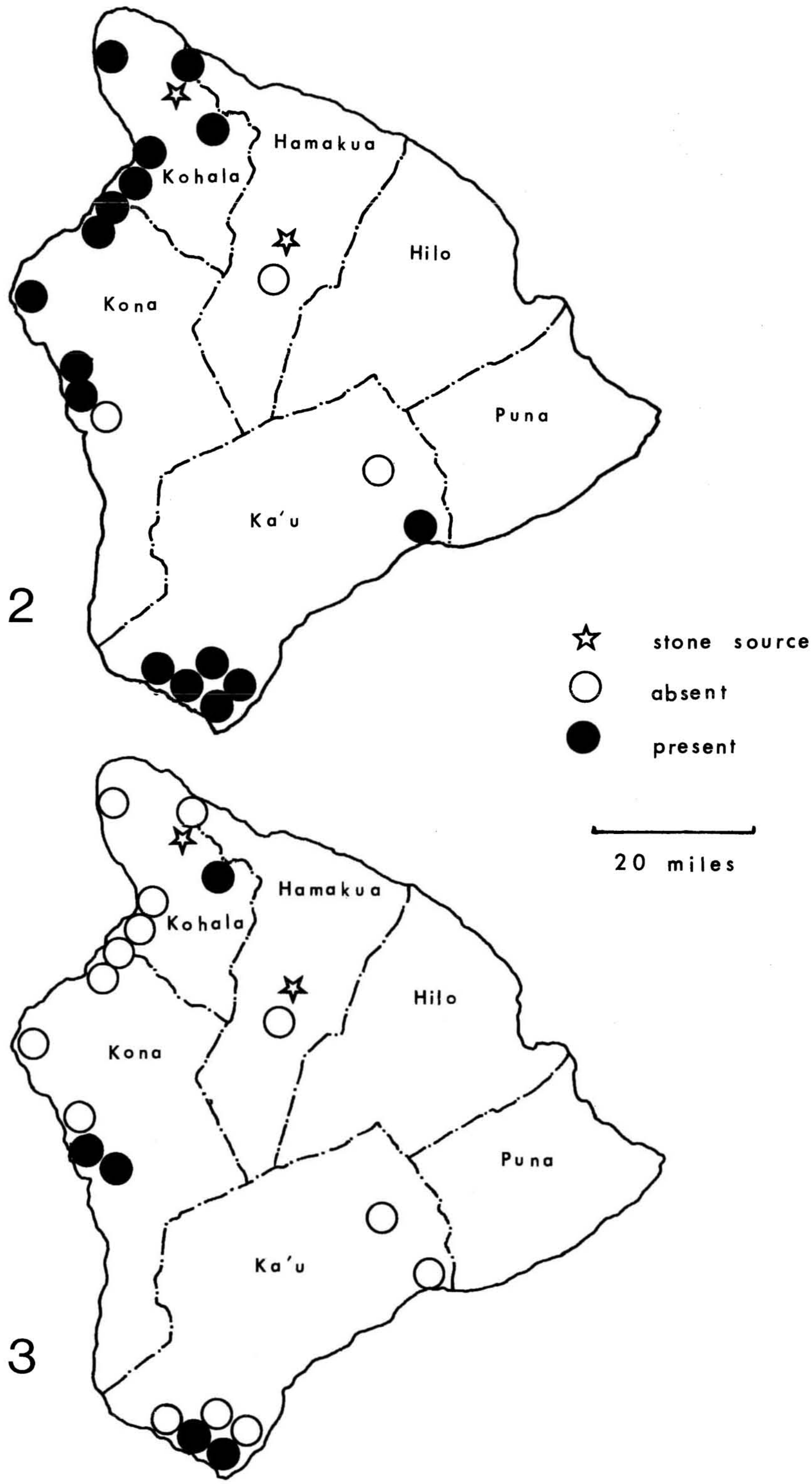
Spatial Distribution

When the spatial distribution of raw material types is examined, it is apparent that Mauna Kea material is widely distributed (Fig. 2). It is found at all but 3 of the 19 localities from which artifacts were analyzed; in each of these 3 areas only 1 artifact from 1 archaeological site was subjected to petrographic analysis, so small sample size may account for the absence of Mauna Kea material. Although occurring less frequently than Mauna Kea material, the other material types also seem to be widely found with no evidence of local concentrations (Figs. 3–8). There may be a slight concentration of Type A, Type B, and Type D materials in the southern part of Hawai'i Island, but they are not restricted solely to this area, and the small numbers in which artifacts of these types occur may result in some bias.

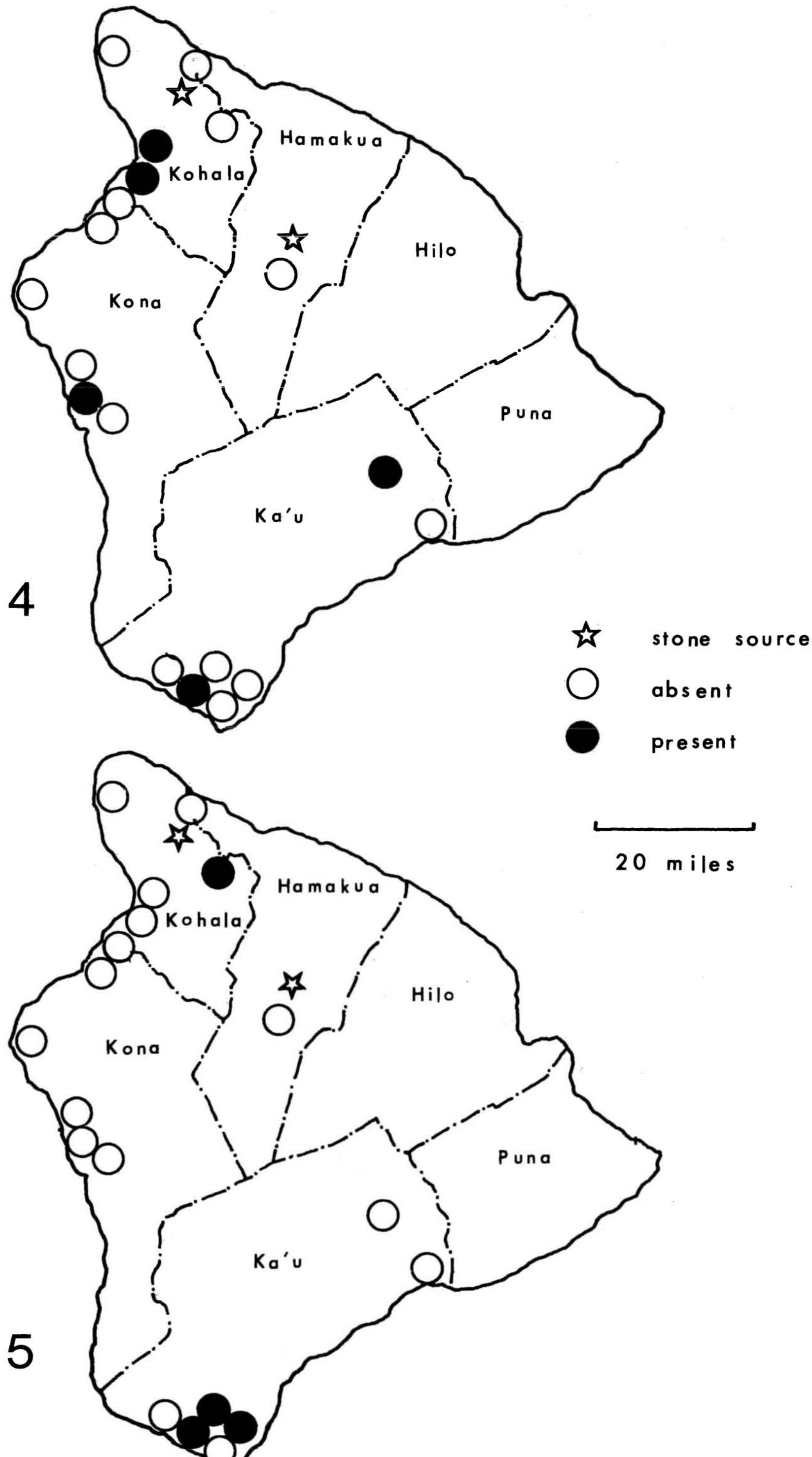
It is also apparent from the spatial distribution of stone types that artifacts are not necessarily found at sites closest to their sources; the fact that the source of the largest number of artifacts, Mauna Kea, is centrally located on Hawai'i Island may account for some of this lack of patterning, but the other material types seem to be more or less randomly distributed as well. Also interesting is that more than one material type is commonly found among the artifacts of a single site and/or locality, showing that a variety of raw materials was available to specific local areas.

Temporal Distribution

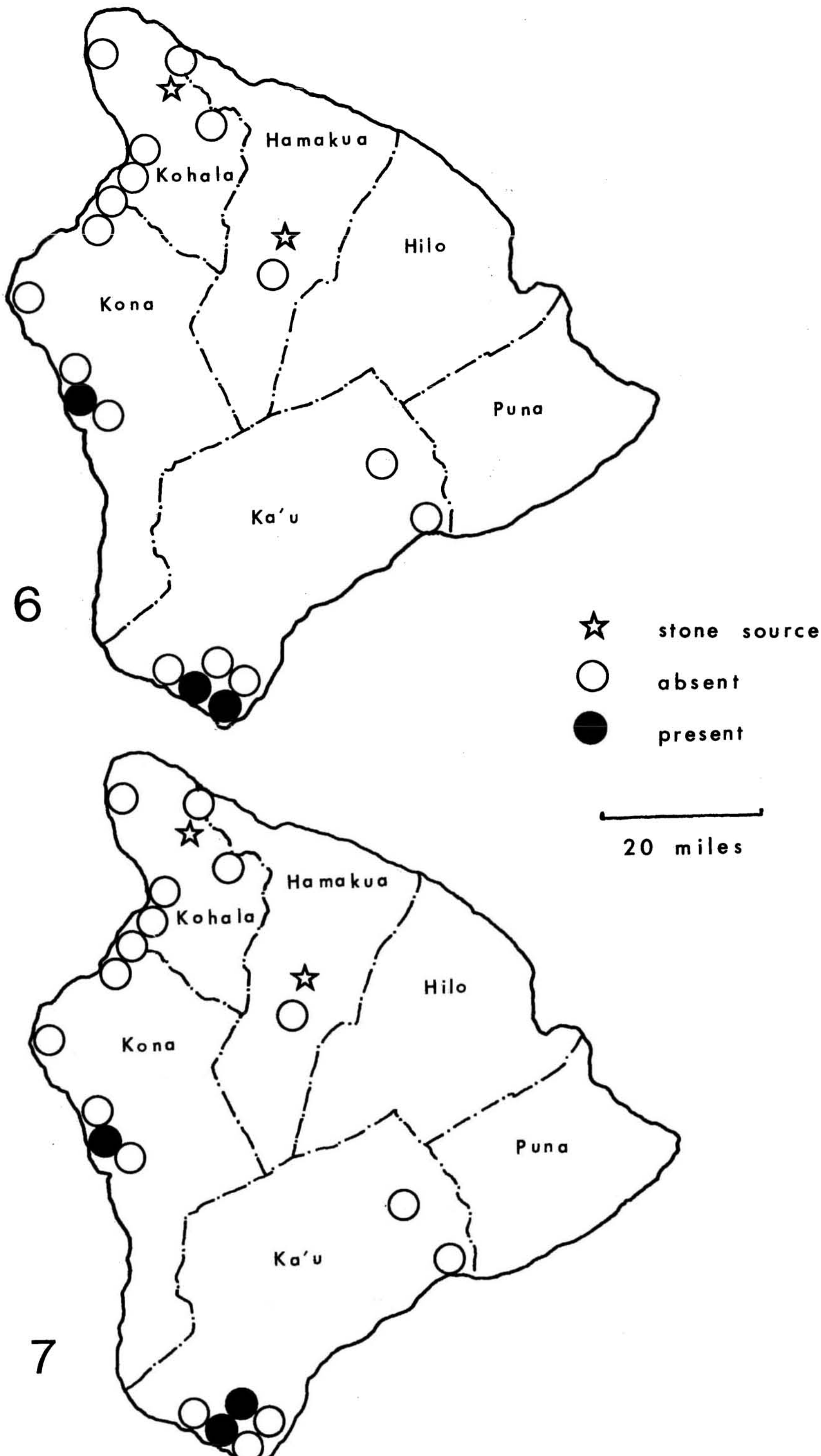
Temporally, all raw material types are found at sites of an early date and in the same frequencies throughout the chronological sequence. There is perhaps a tenden-



Figs. 2–3. Distribution of Mauna Kea and Pololū materials on Hawai'i Island: 2, Mauna Kea material; 3, Pololū material.



Figs. 4–5. Distribution of Kīlauea and type A materials on Hawai'i Island: 4, Kīlauea material; 5, type A material.



Figs. 6–7. Distribution of type B and type D materials on Hawai'i Island: 6, type B material; 7, type D material.

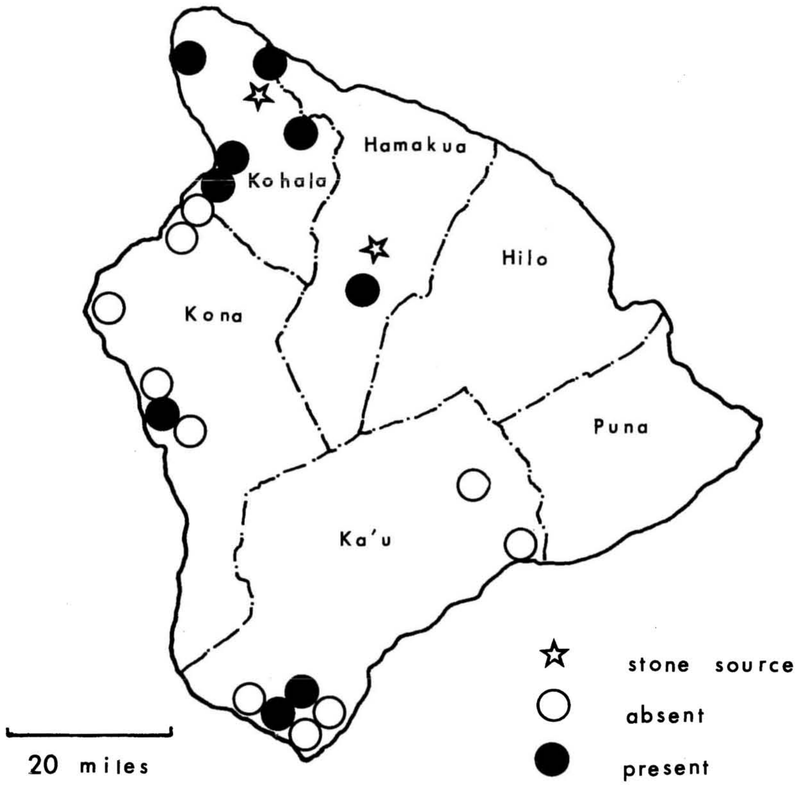


Fig. 8. Distribution of unknown materials on Hawai'i Island.

cy for some materials, such as Type D, to be absent from more recent time periods, but this is probably accounted for by small sample size. There appears to be no change in the spatial distribution of various materials over time; the overall random patterning described above seems to occur in every time period. When the sites from which artifacts were analyzed are arranged from north to south and in chronological order, no clear-cut trends can be seen (Tables 3–7).

INTERPRETATION

Numerous models and hypotheses correlating archaeological distributions with mechanisms of prehistoric exchange have been proposed. One of the most commonly used approaches involves measuring changes in the abundance (e.g., Renfrew 1975, 1977) or the frequency (e.g., McBryde 1978, 1984; McBryde and Harrison 1981) of different material types with distance from their sources. Data are used to detect "fall-off curves," which in theory are distinctive according to the type of prehistoric exchange. These models suggest that with direct access and/or down-the-line exchange there is a clear "distance decay effect" in the occurrence of materials as distance from the source increases. This effect is absent in the case of redistribution.

If these hypotheses are applied to the Hawaiian data presented above, direct access

TABLE 3. MATERIALS AT DATED SITES, BEFORE A.D. 1100

SITE (NUMBER OF ARTIFACTS)	MAUNA KEA	POLOLŪ	KĪLAUEA	TYPE A	TYPE B	TYPE D	UNKNOWN
H8 (15)	x	x	x	x	x	x	x
H1 (5)	x	x			x		
All (20)	x	x	x	x	x	x	x

TABLE 4. MATERIALS AT DATED SITES, A.D. 1400–1650

SITE (NUMBER OF ARTIFACTS)	MAUNA KEA	POLOLŪ	KĪLAUEA	TYPE A	TYPE B	TYPE D	UNKNOWN
Kalahuipua'a 324 (7)	x		x				
Kalahuipua'a 368 (8)	x						x
Kailua-Kawaihae 701A (4)	x						
Bobcat Trail 5004 (1)							x
Kahalu'u D4-48 (1)						x	
Kahalu'u D4-51 (1)	x						
Kahalu'u 7702 (4)	x						x
All (26)	x		x			x	x

TABLE 5. MATERIALS AT DATED SITES, A.D. 1650–1800

SITE (NUMBER OF ARTIFACTS)	MAUNA KEA	POLOLŪ	KĪLAUEA	TYPE A	TYPE B	TYPE D	UNKNOWN
Mudlane 2727 (3)	x						x
Mudlane 5998 (2)	x	x					
Mudlane 8825 (2)	x						
Ouli 5625 (1)	x						
Ouli 5627 (2)			x				x
Ouli 8010 (1)	x						
Ouli 8018 (3)	x						
Kalaoa 4-16-6 (1)	x						
Kuakini D6-21 (1)	x						
Kuakini D6-41 (3)	x						
Kuakini D7-27 (3)	x						
Kuakini D8-52 (1)	x						
Kahalu'u 5611 (3)	x						
Kahalu'u 7702 (27)	x	x	x		x		x
"Helco" T-1 (1)		x					
H2 (2)	x			x			
All (56)	x	x	x	x	x		x

TABLE 6. MATERIALS AT DATED SITES, AFTER A.D. 1800

SITE (NUMBER OF ARTIFACTS)	MAUNA KEA	POLOLŪ	KĪLAUEA	TYPE A	TYPE B	TYPE D	UNKNOWN
Mudlane 2732 (8)	x			x			x
Mudlane 2776 (9)	x						
Mudlane 8824 (2)	x						
Anaehoomalu 303 (1)	x						
Pu'ueo 73 (1)	x						
All (21)	x			x			x

TABLE 7. MATERIALS AT DATED SITES, LONG SEQUENCES

SITE (NUMBER OF ARTIFACTS)	MAUNA KEA	POLOLŪ	KĪLAUEA	TYPE A	TYPE B	TYPE D	UNKNOWN
Lapakahi 6941 (5)	x						x
Kalahuipua'a 355 (7)	x		x				
Kailua-Kawaihae 1349 (1)	x						
H65 (3)	x						
Waiahukini 22-64 (6)	x			x		x	x
Waiahukini 22-248 (3)	x						
All (25)	x		x	x		x	x

and down-the-line exchange are not indicated by the widespread random distributions of the various material types. Rather, some sort of centralized exchange system that ensured distribution of all material types to all parts of Hawai'i Island is suggested. However, setting aside some of the larger problems inherent in using distance decay models, I do not think such models are well suited for interpreting the Hawaiian data presented here. First, the data on Hawaiian raw material types, unlike that used in most other exchange studies, cannot be assumed to be actually representative of the amounts or frequencies of different materials at archaeological sites. More important, there are several geographical factors that make predictions involving distance decay inappropriate. These include: (1) the probability of sea travel along the coast of Hawai'i Island; (2) the relatively short land or sea distances involved in traveling from any given material source to any other location on the island; and (3) the central location of the largest and probably preferred source, the Mauna Kea Quarry.

The data presented here can be used to argue against the existence of a centralized or redistributional system involving adze stone. First, the apparent use of many local sources in addition to the Mauna Kea Quarry suggests that there was not a centralized, far-reaching system of stone distribution, or else a greater reliance on the apparently superior Mauna Kea material would probably be seen. It has been suggested (Ericson 1984:7) that high-quality or preferred materials may be subject to centralized control at the same time that secondary sources are not, but there is no evidence that the distribution of Mauna Kea material differed significantly from the distribution of other materials. Second, there is no change over time in the distribution patterns of any of the materials, and such change would be expected if centralized control of stone resources accompanied or developed with the other trends toward cultural complexity that have been documented in Hawaiian chiefdoms.

There are other interpretations of prehistoric exchange that I think apply to the distributional patterns seen in the Hawaiian data presented here. Clark (1965), for example, in his discussion of stone axe trade, proposed that when unsystematic "gift-exchange" rather than some sort of "purposive trade" was the mechanism of axe distribution, the archaeological distribution patterns are characterized by "a much more complex situation with lines of diffusion crossing in a bewildering manner and the products of two or more factories converging on particular sites at the same time" (Clark 1965:27). His description of the "complex situation" produced by exchange based on nonpurposive, inter-personal ties seems to describe the apparently random and nonpatterned distribution of adze materials on Hawai'i Island.

I propose that the distribution of adze stone, or perhaps more accurately, adze preforms, on Hawai'i Island was accomplished through informal, inter-personal exchange and/or occasional direct trips to various quarries facilitated by easy sea travel, short travel distances, and the typically dispersed Hawaiian settlement pattern that encouraged mobility on the part of individuals. I think this interpretation accounts for: (1) the widespread yet unpatterned spatial distribution of adze stone types; (2) the use of many stone sources, including what may have been numerous small quarries and/or isolated sources; and (3) the apparent lack of change in distribution patterns over time as this unregulated system of exchange and acquisition simply continued without involvement in increasing cultural complexity.

The nature of the adze stone resource itself would have been well suited to informal and occasional distribution; unlike obsidian, adze stone was not distributed as a raw material that could be put to varied uses, but rather as nearly finished, specific-purpose tools that had a relatively long use-life and were not highly portable or storable if amassed for some sort of more formal or regulated distribution. Occasional trips to quarries or exchange with other individuals could easily have been an efficient and effective way to acquire adzes.

In conclusion, my research seems to suggest that centralized redistribution of adze stone did not take place on Hawai'i Island. Archaeological evidence does not support the idea that redistribution of necessary resources was a key factor in the development of complex chiefdoms in Hawai'i. This is consistent with Earle's notion of a "subsistence economy" with reciprocal, informal exchange systems that was distinct from the "political economy" characterized by redistributional "taxation."

As tools used in such important tasks as agricultural clearing, house construction, and canoe making (a task probably performed by craft specialists), adzes may have played an interesting role in both aspects of the Hawaiian economy. Certain aspects of their use may have been controlled by the larger political sphere. Further research on adze production at quarry sites, the contexts of adze use or loss, and the distribution of raw materials by tool type or site type may provide further information on the possible role of these items in the development of Hawaiian chiefdoms.

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